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Design Of Vertical Pressure Vessel Using Pvelite Software

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Abstract

Pressure vessels are widely used in various industries. A vertical pressure vessel has been designed using graphical based software named PVElite. For designing of vertical leg supported pressure vessel some input parameters like volume, inside diameter, design pressure (either inside pressure or external pressure), temperature, material, processing fluid. Etc. is required. PVElite gives thickness of shell, thickness of head, height of head, thickness of nozzle, manhole. The high stresses at intersections are caused by discontinuity shear stresses and moments which exist to maintain compatibility at the junctions. PVElite calculate this local stresses according to welding research council (WRC) 107.

Key words: Vertical Pressure Vessel, Design using PVElite, Local stress analysis using PVElite.

1. INTRODUCTION

Pressure vessels are the container for fluid and gases under high pressure. Due to high pressure, stresses are induced in pressure vessel, if this stresses are more than the permissible stresses then the failure of pressure vessel occurs. So it is necessary to manufacture pressure vessels under standard codes. A **code** is a standard that has been adopted by one or more governmental bodies and has the force of law, or when it has been incorporated into a business contract. Codes specify requirements of design, fabrication, inspection and testing of pressure vessels. A detailed study of various parts of pressure vessels like shell, head support, flanges, nozzles etc. is carried out according to rules of ASME code section VIII, Division I. Due to mathematical calculation designing of pressure vessel becomes tedious but by using software like PVElite designing of pressure vessel can be done easily. In the case of shell, opening requiring reinforcement in vessel under internal pressure the metal removed must be replaced by the metal of reinforcement. In addition to providing the area of reinforcement, adequate welds must be provided to attach the metal of reinforcement and the induced stresses must be evaluated.

2. ANALYSIS OF PRESSURE VESSEL USING PVELITE AND DISCUSSION

2.1 Design condition

Design pressure: 0.245 MPa

Design temperature: 150 ċ

Material: SA240 M 316L

Corrosion allowance: Nil

process fluid : D M Water (Non – Lethal)

Process fluid sp. Gravity: 1.00

Wind load/ snow load: Not applicable

Seismic load: AS per IS-1893, Zone III

2.2 Result and Discussion

In PVElite software we have to enter input data that is required for pressure vessel element and then we have to select its components like head, shell, pipe and legs etc. And its calculate its o/p value like thickness, shell/head height and all other result as show in bellow. Pressure vessel contains fluid so while designing we have to also consider static pressure due to fluid. Static pressure is equal p * g * h. Where, p= density of fluid, g= gravity and h= height up to which vessel contain fluid.
PVElite also show analyzes result as follow:
Inside Corroded Head Depth [h]:
= L – Sqrt ((L - Di / 2) * (L + Di / 2 - 2 * r))

= 1000.00 –Sqrt ((1000.00 -1000.00 /2)*(1000.00 +1000.00 /2-2*100.00))
= 193.774 mm.
M factor for Torispherical Head:
= (3+sqrt ((L+CA)/(r + CA))) /4 per Appendix 1-4 (b & d)
= (3+sqrt ((1000.000 +0.0000)/ (100.000 +0.0000)))/4
= 1.540

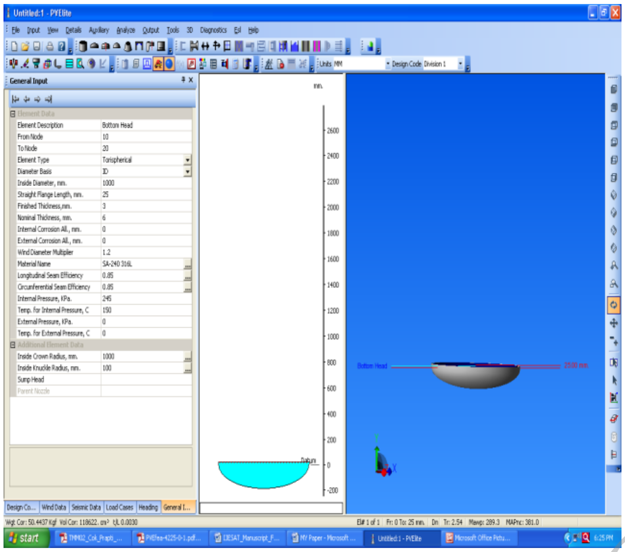

Fig. 1 torispherical head

Thickness Due to Internal Pressure [Tr]:
= (P*(L+CA)*M)/(2*S*E-0.2*P) per Appendix 1-4 (d)
= (259.397*(1000.0000+0.0000)*1.5406)/(2*87.43*0.85-0.2*259.397)
= 2.6898 + 0.0000 = 2.6898 mm.

Max. All. Working Pressure at Given Thickness [MAWP]:
Less Operating Hydrostatic Head Pressure of 14.397 KPa.
= (2*S*E*(T-CA))/(M*(L+CA)+0.2*(T-CA)) per Appendix 1-4 (d)
= (2*87.43*0.85*(3.0000))/(1.5406*(1000.0000+0.0000)+0.2*(3.0000))
= 289.305 - 14.397 = 274.908 KPa.

Actual stress at given pressure and thickness [Sact]:
= (P*(M*(L+CA)+0.2*(T-CA)))/(2*E*(T-CA))
= (259.397*(1.5406*(1000.0000+0.0000)+0.2*(3.0000)))/(2*0.85*(3.0000))
= 78.392 N./mm²

Required Thickness of Straight Flange = 1.749 mm.
Percent Elongation per UHA-44 (75*tnom/Rf)*(1-Rf/Ro) 4.369 %

Generally industry used mm unit system but we can change it into other system because soft ware provide this facility and also design code are given so can use any of it. For pressure vessel we used ASME SEC VIII division I and also material can change and according to material software used material's all data like max. Allowable stress etc.

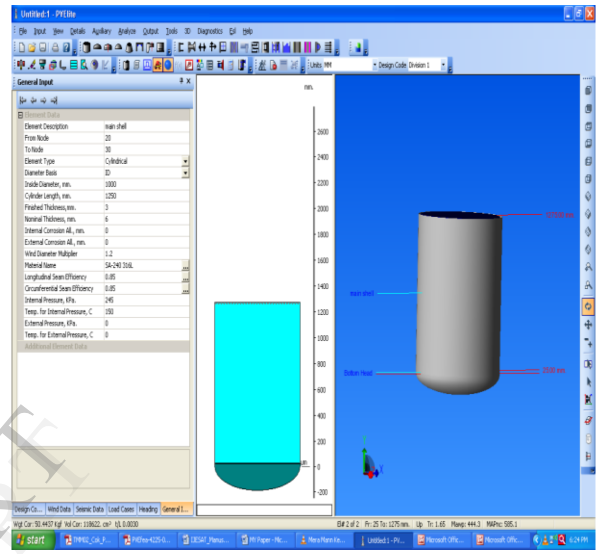

Fig. 2 cylindrical shell input parameter

Thickness Due to Internal Pressure [Tr]:
= (P*(D/2+Ca))/(S*E-0.6*P) per UG-27 (c)(1)
= (257.253*(1000.0000/2+0.0000))/(87.43*0.85-0.6*257.253)
= 1.7345 + 0.0000 = 1.7345 mm.

Max. All. Working Pressure at Given Thickness [MAWP]:
Less Operating Hydrostatic Head Pressure of 12.253 KPa.
= (S*E*(T-Ca))/((D/2+Ca)+0.6*(T-Ca)) per UG-27 (c)(1)
= (87.43*0.85*(2.0000))/((1000.0000/2+0.0000)+0.6*2.0000)
= 296.534 - 12.253 = 284.282 KPa.

Actual stress at given pressure and thickness [Sact]:
= (P*((D/2+CA)+0.6*(T-CA)))/(E*(T-CA)) = (257.253*((1000.0000/2+0.0000)+0.6*(2.0000)))/(0.85*(2.0000))
= 75.849 N./mm²

Percent Elongation per UHA-44 (50*tnom/Rf)*(1-Rf/Ro) 0.596 %

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In this pressure vessel there are four nozzles including manhole. Here I show only one manhole's input parameter and its calculation given by PVElite. Here I selectee nozzle with RF pad and input all parameter including nozzle orientation.

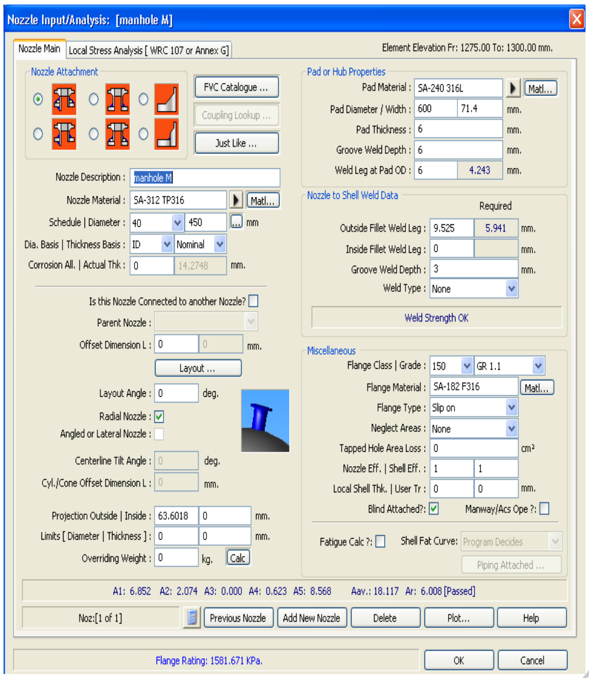

Fig. 3 manhole M input parameter

Nozzle Sketch

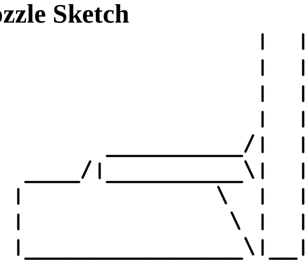

Fig. 4 Insert Nozzle with Pad, no inside projection

NOZZLE CALCULATION, Description: man hole M

ASME Code, Section VIII, Division 1, 2007, UG-37 to UG-45

Actual Nozzle Inside Diameter Used in Calculation 428.650 mm.
Actual Nozzle Thickness Used in Calculation 14.275 mm.

Nozzle input data check completed without errors.

Reqd thickness per UG-37(a)of Torispherical Head, Tr [Int. Press]
= (P*(L+CA)*M)/(2*S*E-0.2*P) App. 1-4 (d)
= (245.00*(1000.0000+0.0000)*1.00)/(2*87*1.00-0.2*245.00)
= 1.4016 mm.

Reqd thickness per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*(D/2+CA))/(S*E-0.6*P) per UG-27 (c)(1)
= (245.00*(428.6504/2+0.0000))/(87*1.00-0.6*245.00)
= 0.6016 mm.

UG-40, Thickness and Diameter Limit Results : [Int. Press]

Effective material diameter limit, Dl 857.3008 mm.
Effective material thickness limit, no pad Tlnp 7.5000 mm.
Effective material thickness limit, pad side Tlwp 7.5000 mm.

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5
Area Required , Ar 6.008 cm²
Area in Shell, A1 6.852 cm²
Area in Nozzle Wall, A2 = 2.051 cm²
Area in Inward Nozzle, A3 = 0.000 cm²
Area in Welds,A4 = 0.407 cm²
Area in Pad , A5 = 8.568 cm²
TOTAL AREA AVAILABLE, Atot = 17.878 cm²
The Internal Pressure Case Governs the Analysis.
Nozzle Angle Used in Area Calculations 90.00 Degs.
The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.
Reinforcement Area Required for Nozzle [Ar]:
= (Dlr*Tr+2*Thk*Tr*(1-fr1)) UG-37(c)
= (428.6504*1.4016+2*(14.2748-0.0000)*1.4016*(1-1.0000))
= 6.008 cm²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:
= (DL-Dlr)*(ES*(T-Cas)-Tr)-2*(Thk-Can)*(ES*(T-Cas)-Tr)*(1-fr1)
= (857.301-428.650)*(1.00*(3.0000-0.000)-1.402)-2*(14.275-0.000)
(1.00(3.0000-0.0000)-1.4016)*(1-1.0000)
= 6.852 cm²

Area Available in Nozzle Wall, no Pad [A2np]:
= (2 * min(Tlnp,ho)) * (Thk - Can - Trn) * fr2
= (2 * min(7.50 ,63.60)) * (14.27 - 0.00 - 0.60) * 1.0000)
= 2.051 cm²

Area Available in Nozzle Wall, with Pad [A2wp]:
= (2 * Tlwp)*(Thk - Can - Trn)* fr2
= (2 * 7.5000) * (14.2748 - 0.0000 - 0.6016) * 1.0000

Area Available in Welds, no Pad [A4np]:
= Wo^2 * fr2 + (Wi-Can/0.707 $)^2$ * fr2
= 6.0000^2 * 1.0000 + $(0.0000)^2$ * 1.0000
= 0.360 cm^2

Area Available in Welds, with Pad [A4wp]:
= (Wo^2 - Ar Lost)*Fr3+((Wi-Can/0.707$)^2$ - Ar Lost)*Fr2 + Wp^2*Fr4
= (0.1575) * 1.00 + (0.0000) * 1.00 + 25.0000^2 * 1.00
= 0.407 cm^2

Area Available in Pad [A5]:
= (min (Dp, DL)-(Nozzle OD))*(min (Tp, Tlwp, Te))*fr4
= (600.0000 - 457.2000) * 6.0000 * 1.00
= 8.568 cm^2

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness per UG45 (a), tra = 0.6016 mm.
Wall Thickness per UG16 (b), tr16b = 1.5875 mm.
Wall Thickness per UG45 (b) (1), trb1 = 2.1592 mm.
Check UG16 (b) Min. Thickness, trb1 = Max (trb1, tr16b) = 2.1592 mm.
Std. Wall Pipe per UG45 (b)(4), trb4 = 8.3344 mm.
Wall Thickness per UG45 (b),
trb = Min(trb1, trb4) = 2.1592 mm.

Final Required Thickness, tr45 = Max (tra, trb) = 2.1592 mm.
Available Nozzle Neck Thickness = .875 * 14.2748 = 12.4905 mm. --> OK

M.A.W.P. Results for this Nozzle (Based on Areas) at this Location Approximate M.A.W.P. for given geometry 289.305 KPa.

Weld Size Calculations, Description: man hole M

Intermediate Calc. for nozzle/shell Welds Tmin 6.0000 mm. Intermediate Calc. for pad/shell Welds Tmin Pad 6.0000 mm.

Results Per UW-16.1:
Required Thickness Actual Thickness
Nozzle Weld4.2000 = 0.7 *TMIN 4.2420 = 0.7 * WO mm.
Pad Weld 3.0000 = 0.5*Tmin Pad 3.5350 = 0.7 * WP mm.

The Drop for this Nozzle is: 26.3982 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T: 93.0000 mm.

Manhole or hand hole is required for inspection or cleaning and repair work and which one is selected is depend on pressure vessel diameter .As per UG-46 (f) (1) vessel less than 450 mm & over 300 mm I.D should have at least two hand hole and I.D more than it should have man hole. According to UG-46 (g) (1) a circular manhole shall not be less than 400 mm I.D. Below Figure show input parameter and analysis of leg support with base plate.

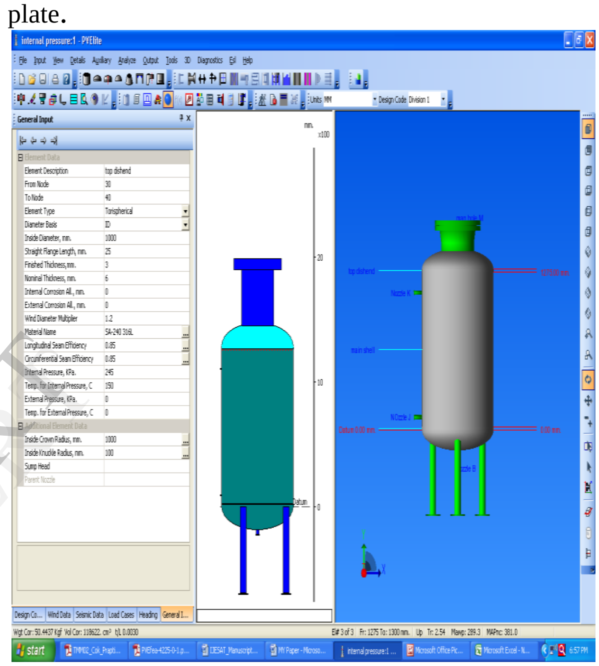

Fig. 5 Pipe Leg support input parameter

RESULTS FOR LEGS: Hydro Test Case Description: LEGS

Legs attached to: bottom dishend

Section Properties: Circular Steel Pipe: PIPE

India ISI Structural Steel Data

Leg Length from Attachment to Base		
Leglen		700.000 mm.
Number of Legs	Nleg	3
Cross Sectional Area for PIPE	Aleg	14.377 cm^2
Section Inertia (strong axis)		125.583 cm**4
Section Inertia (weak axis)		125.583 cm**4
Section Modulus (strong axis)		28252.760 $mm.^3$
Section Modulus (weak axis)		28252.760 $mm.^3$
Radius of Gyration (strong axis)		29.555 mm.
Radius of Gyration (weak axis)		29.555 mm.

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Leg Orientation - Strong Axis

Overturning Moment at top of Legs 0.0 Kg-m.
Total Weight Load at top of Legs, W 1574.2 Kgf
Total Shear force at top of Legs 0.0 Kgf
Additional force in Leg due to Bracing, Fadd 0 Kgf
Occasional Load Factor , Occfac 1.000
Effective Leg End Condition Factor, k 1.000
Pipe Leg inside Diameter 77.927 mm.
Pipe Leg outside Diameter 88.900 mm
Note: The Legs are Not Cross Braced
The Leg Shear Force includes Wind and Seismic Effects

Maximum Shear at top of one Leg [Vleg]:
= (Max (Wind, Seismic) + Fadd) * (Imax / Itot)
= (0.0 + 0.0) * (125.6 / 376.75)
= 0.00 Kgf
Axial Compression, Leg furthest from N.A. [Sma]
= ((W/Nleg) + (Mleg/(Nlegm*Rn)))/Aleg)
= ((1574 / 3) + (0 /(1 * 547.45)))/ 14.377)
= 3.58 N /mm^2
Axial Compression, Leg closest to N.A. [Sva]
= (W / Nleg) / Aleg
= (1574 / 3) / 14.377
= 3.58 N./mm^2
Allowable Comp. for the Selected Leg (KL/r < Cc) [Sa]:
= Occfac * (1-$(kl/r)^2/(2*Cc^2)$)*Fy /
(5/3+3*(Kl/r)/(8*Cc)-$(Kl/r^3)/(8*Cc^3)$)
= 1.00 * (1-$(23.68)^2/(2 * 127.18^2)$) * 248 /
(5/3+3*(23.68)/(8* 127.18)-($23.68^3)/(8*127.18^3)$)
= 140.53 N./mm^2
Bending at the Bottom of the Leg closest to the N.A. [S]:
= (Vleg * Leglen * 12 / Smdsa)
= (0.00 * 700.00 * 12 / 28252.76)
= 0.00 N./mm^2
Allowable Bending Stress [Sa]:
= (0.6 * Fy * Occfac)
= (0.6 * 248 * 1.00)
= 148.93 N./mm^2
AISC Unity Check [Sc](must be < or = to 1.00) :
= (Sma/Sa)+(0.85*S)/((1-Sma/Spex)*Sb)
= (3 /140)+(0.85 *0.000)/((1 -3 /1867) *148)
= 0.0255

LEG BASEPLATE Analysis, including Moments

Pipe Leg
Base Plate Available Area (AA):
= B * D
= 150.00 * 150.00
= 225.00 cm^2
Clearance between the Bolt and the Leg Edge (BCL):
= z - BOD / 2
= 20.00 - 16.00 / 2
= 12.00 mm.
Moment at Base plate (MOMENT):
= Vleg * Lleg
= 0.00 * 700.00
= 0.00 Kg-m.
Bearing Pressure (FC):
= P / AA
= 524.72 / 225.00
= 228.69 KPa.
m = (MAX (B, D) - 0.707 * POD) / 2.0
= (150.00 - 0.707 * 0.00) / 2.0
= 43.57 mm.
The Base plate Required Thickness (TREQ):
= (3 * FC * m^2 / (1.5 * SBA)) ½
= (3 * 228.69 * 43.57^2 / 206.85)½
= 2.51 mm.
Base plate Lifting Moment (MBB):
= Rmleg + V * Length
= 0.00 + 0.00 * 700.00
= 0.00 Kg-m.
Required Total Bolt Area per Leg (ABREQB): per H. Bednar
= (1 / STBA) * ((4 * MBB / (Nlegm * OD)) - P)
= (1 / 129.63) * ((4 * 0.00 / (1 * 1006.00)) - 524.72)
= -0.3970 cm^2 --> (No tension in bolts)
Summary of Results:

	Actual	Required	Pass/Fail
Base plate Thickness (mm.):	14.000	2.510	Pass
Bolt Root Area (D. Moss)(cm^2):	1.44	0.00	Pass

3. LOCAL STRESSES ANALYSIS USING PVELITE

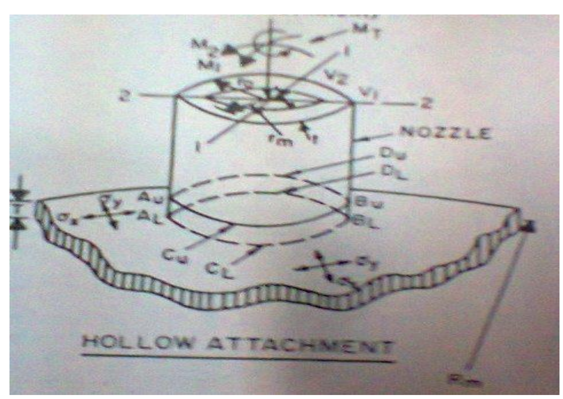

Fig. 6 hollow attachment at shell

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When pressure vessels have to be connected to a piping system, the attachment of nozzles to the crown becomes inevitable. There have been numerous detailed analyses of torispherical shells with radial nozzles, being subjected to various loadings. The nozzle has been singled out as a potential source of weakness in the sense that high stresses occur here. If stresses are within the limit than PVElite shown joint is safe. Here only radial load and shear force V2 is consider and shear force V1 is not consider because of unidirectional loading and moment doe to this force are not excepted in this example. Local stress analysis of manhole's input parameter window is shown below.

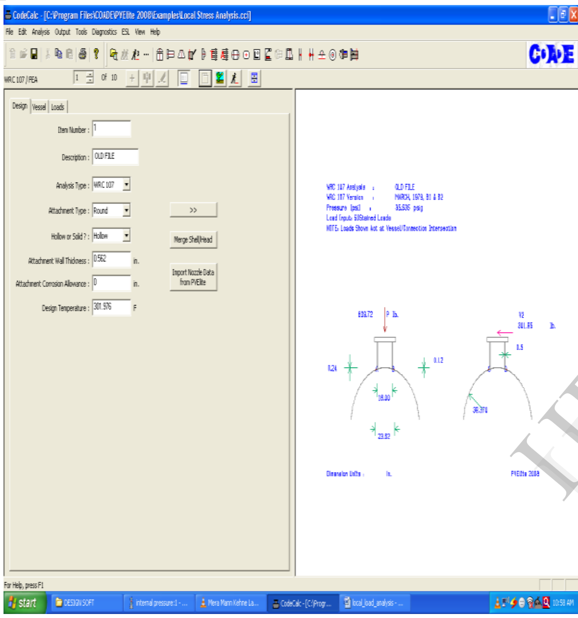

Fig.7 Local stress analysis of man hole

Input Echo, WRC107 Item 1,
Description: manhole M

Diameter Basis for Vessel	Vbasis	ID
Cylindrical or Spherical Vessel	Cylsph	Spherical
Corrosion Allowance for Vessel	Cas	0.0000 in.
Vessel Diameter	Dv	78.740 in.
Vessel Thickness	Tv	0.118 in.
Design Temperature		301.98 F
Vessel Material		SA-240 316L
Vessel Cold S.I. Allowable	Smc	16700.00 psi
Vessel Hot S.I. Allowable	Smh	12680.24 psi
Attachment Type	Type	Round
WRC107 Attachment Classification,	Holsol	Hollow
Diameter Basis for Nozzle	Nbasis	ID
Corrosion Allowance for Nozzle	Can	0.0000 in.
Nozzle Diameter	Dn	16.876 in.
Nozzle Thickness	Tn	0.562 in.
Nozzle Material		SA-312 TP316L
Nozzle Cold S.I. Allowable	SNmc	16700.00 psi
Nozzle Hot S.I. Allowable	SNmh	12680.24 psi
Thickness of Reinforcing Pad	Tpad	0.236 in.
Diameter of Reinforcing Pad	Dpad	23.622 in.
Design Internal Pressure	Dp	35.535 psig
Include Pressure Thrust		No

External Forces and Moments in WRC 107 Convention:

Radial Load (SUS)	P	839.7 lb.
Longitudinal Shear (SUS)	(Vl) V1	0.0 lb.
Circumferential Shear (SUS)	(Vc) V2	301.9 lb.
Circumferential Moment (SUS)	(Mc) M1	0.0 ft.lb.
Longitudinal Moment (SUS)	(Ml) M2	0.0 ft.lb.
Torsional Moment (SUS)	Mt	0.0 ft.lb.

Use Interactive Control No
WRC107 Version Version March 1979 (B1 & B2)

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for Sustained loads:

Radial Load	P	839.7 lb.
Circumferential Shear	(VC) V2	301.9 lb.
Longitudinal Shear	(VL) V1	0.0 lb.
Circumferential Moment	(MC) M1	0.0 ft.lb.
Longitudinal Moment	(ML) M2	0.0 ft.lb.
Torsional Moment	MT	0.0 ft.lb.

Dimensionless Parameter:
U = 2.40
TAU = 15.51
RHO = 4.00 (0.63)

Below all value taken from respective figure than given in welding Research council bulletin 107. By using PVElite software its easy to get its value and reduce time otherwise we have to do little iteration and its tedious work.

Dimensionless Loads for Spherical Shells at Attachment Junction:

Curves read for 1979 B1/B2 Location	Figure	Value
N(x) * T / P	SP 7	0.02237
M(x) / P	SP 7	0.00205
N(x)*T *SQRT(Rm * T) /MC	SM 7	0.02019
M(x) *SQRT(Rm * T) /MC	SM 7	0.00160
N(x) * T *SQRT(Rm * T) /ML	SM 7	0.02019
M(x) *SQRT(Rm * T) /ML	SM 7	0.00160
N(y) * T / P	SP 7	0.02957
M(y) / P	SP 7	0.00406
N(y) * T * SQRT (Rm * T) / MC	SM 7	0.03386
M(y) * SQRT (Rm * T) / MC	SM 7	0.00292

N(y) * T * SQRT (Rm * T) / ML	SM 7	0.03386
M(y) * SQRT (Rm * T) / ML	SM 7	0.00292

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction:

Type of Stress	Load	Stress Values at (psi) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Memb.	P	-149	-149	-149	-149	-149	-149	-149	-149
Rad. Bend.	P	-82	82	-82	82	-82	82	-82	82
Rad. Memb.	MC	0	0	0	0	0	0	0	0
Rad. Bend.	MC	0	0	0	0	0	0	0	0
Rad. Memb.	ML	0	0	0	0	0	0	0	0
Rad. Bend.	ML	0	0	0	0	0	0	0	0
Tot. Rad. Str.		-231	-67	-231	-67	-231	-67	-231	-67
Tang. Memb.	P	-197	-197	-197	-197	-197	-197	-197	-197
Tang. Bend.	P	-162	162	-162	162	-162	162	-162	162
Tang. Memb.	MC	0	0	0	0	0	0	0	0
Tang. Bend.	MC	0	0	0	0	0	0	0	0
Tang. Memb.	ML	0	0	0	0	0	0	0	0
Tang. Bend.	ML	0	0	0	0	0	0	0	0
Tot. Tang. Str.		-360	-34	-360	-34	-360	-34	-360	-34
Shear	VC	30	30	-30	-30	0	0	0	0
Shear	VL	0	0	0	0	0	0	0	0
Shear	MT	0	0	0	0	0	0	0	0
Tot. Shear		30	30	-30	-30	0	0	0	0
Str. Int.		367	85	367	85	360	67	360	67

Unit less Prm:
U = 5.47
TAU = 0.00 (20.52)
RHO = 0.00 (0.21)

Dimensionless Loads for Spherical Shells at Pad edge:

Curves read for 1979 B1/B2	Figure	Value
N(x) * T / P	SR 2	0.02175
M(x) / P	SR 2	0.00990
N(x) * T * SQRT(Rm * T) / MC	SR 3	0.01691
M(x) * SQRT(Rm * T) / MC	SR 3	0.01053
N(x) * T * SQRT(Rm * T) / ML	SR 3	0.01691
M(x) * SQRT(Rm * T) / ML	SR 3	0.01053
N(y) * T / P	SR 2	0.00650
M(y) / P	SR 2	0.00300
N(y) * T * SQRT(Rm * T) / MC	SR 3	0.00507
M(y) * SQRT(Rm * T) / MC	SR 3	0.00317
N(y) * T * SQRT(Rm * T) / ML	SR 3	0.00507
M(y) * SQRT(Rm * T) / ML	SR 3	0.00317

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad

Type of Stress	Load	Stress Values at (psi) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Memb	p	-1309	-1309	-1309	-1309	-1309	-1309	-1309	-1309
Rad. Bend.	P	-3575	3575	-3575	3575	-3575	3575	-3575	3575
Rad. Memb.	MC	0	0	0	0	0	0	0	0
Rad. Bend.	MC	0	0	0	0	0	0	0	0
Rad. Memb.	ML	0	0	0	0	0	0	0	0
Rad. Bend.	ML	0	0	0	0	0	0	0	0
Tot. Rad. Str.		-4884	2266	-4884	2266	-4884	2266	-4884	2266
Tang. Memb.	P	-391	-391	-391	-391	-391	-391	-391	-391
Tang. Bend		-1083	1083	-1083	1083	-1083	1083	-1083	1083
Tang. Memb.	MC	0	0	0	0	0	0	0	0
Tang. Bend.	MC	0	0	0	0	0	0	0	0
Tang. Memb.	ML	0	0	0	0	0	0	0	0
Tang. Bend.	ML	0	0	0	0	0	0	0	0
Tot. Tang. Str.		-1475	692	-1475	692	-1475	692	-1475	692
Shear	VC	68	68	-68	-68	0	0	0	0
Shear	VL	0	0	0	0	0	0	0	0
Shear	MT	0	0	0	0	0	0	0	0
Tot. Shear		68	68	-68	-68	0	0	0	0
Str. Int.		4886	2269	4886	2269	4884	2266	4884	2266

WRC 107 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.(SUS) Location	Stress Values at (psi) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Pm	1974	1974	1974	1974	1974	1974	1974	1974
Rad. Pl	-149	-149	-149	-149	-149	-149	-149	-149
Rad. Q	-82	82	-82	82	-82	82	-82	82
Long. Pm	1974	1974	1974	1974	1974	1974	1974	1974
Long. Pl	-197	-197	-197	-197	-197	-197	-197	-197
Long. Q	-162	162	-162	162	-162	162	-162	162
Shear Pm	0	0	0	0	0	0	0	0
Shear Pl	30	30	-30	-30	0	0	0	0
Shear Q	0	0	0	0	0	0	0	0
Pm	1974	1974	1974	1974	1974	1974	1974	1974
Pm+Pl	1839	1839	1839	1839	1824	1824	1824	1824
Pm+Pl+Q	1749	1957	1749	1957	1742	1939	1742	1939

Type of Stress Int.	Max. S.I. psi	S.I. Allowable	Result
Pm (SUS)	1974	12680	Passed
Pm+Pl (SUS)	1839	19020	Passed
Pm+Pl+Q (TOTAL)	1957	44070	Passed

WRC 107 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge

Type of Stress Int.	Stress Values at (psi)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Pm	5922	5922	5922	5922	5922	5922	5922	5922
Rad. Pl	-1309	-1309	-1309	-1309	-1309	-1309	-1309	-1309
Rad. Q	-3575	3575	-3575	3575	-3575	3575	-3575	3575
Long. Pm	5922	5922	5922	5922	5922	5922	5922	5922
Long. Pl	-391	-391	-391	-391	-391	-391	-391	-391
Long. Q	-1083	1083	-1083	1083	-1083	1083	-1083	1083
Shear Pm	0	0	0	0	0	0	0	0
Shear Pl	68	68	-68	-68	0	0	0	0
Shear Q	0	0	0	0	0	0	0	0
Pm	5922	5922	5922	5922	5922	5922	5922	5922
Pm+Pl	5536	5536	5536	5536	5531	5531	5531	5531
Pm+Pl+Q	4448	8192	4448	8192	4447	8189	4447	8189

Type of Stress Int.	Max. S.I. psi	S.I. Allowable	Result
Pm (SUS)	5922	12680	Passed
Pm+Pl (SUS)	5536	19020	Passed
Pm+Pl+Q (TOTAL)	8192	44070	Passed

4. Conclusion

Design of pressure vessel by using PVElite gives accurate analysis result and also reduces time. Further research need to explore environmental parameter such as earthquake, thermal load, fluctuation load and so on. Moreover dynamic processes in design need to employ for optimization instead of fixing the input parameter. High stresses occurred at intersection of head and nozzle Welding Research council (WRC) bulletin gives formulation for calculating this stresses.

5. References

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